Virtuality in Teams: A Multilevel Analysis of Its Effects on Innovation and Satisfaction

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Abstract. This study contributes to clarifying how virtuality impacts team innovation and team member satisfaction through its influence on teamwork management. Teamwork management refers to the degree to which team members structure and plan their work to facilitate the implementation of new practices and monitor the work progress and involves the following dimensions: work planning/organization, resource management and support for innovation. Three hundred and fifty-eight team members from 88 teams were surveyed. A two-wave data collection procedure was implemented with a time lag of about two months. Data was collected from two sources: team members were surveyed about virtuality, teamwork management and team member satisfaction, while team leaders assessed the levels of innovation of their teams. Due to the multilevel nature of data (team member satisfaction is at the individual level and the remaining variables at the group level), hypotheses were tested through Generalized Structural Equation Modelling in Stata. Results revealed that the indirect effect of virtuality on innovation through teamwork management was positive and significant, as well as the indirect effect on team member satisfaction. The findings emphasize that virtuality, by encouraging greater engagement in behaviours such as planning work, organizing resources, and providing mutual support, fosters more positive attitudes toward the team and facilitates the introduction of new ideas and procedures.

Keywords: Virtuality · teamwork management · team effectiveness

1 Introduction

Advances in communication and information technologies have fundamentally transformed how organizations structure work. These developments have enabled companies to adopt a wide range of virtual work arrangements that reduce, and in some cases eliminate, traditional constraints of time and physical location. Employees can now collaborate from different cities, countries, or even continents with relative ease (Gibson

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et al., 2023). Although virtual work had already been steadily increasing, the COVID-19 pandemic accelerated this shift dramatically. The sudden and widespread move to remote work during the pandemic represented what many scholars consider one of the most profound job design disruptions of our time (George et al., 2020). Organizations were forced to rethink how work is coordinated, how teams communicate, and how collaboration occurs under conditions of physical separation.

As a result of these changes, contemporary work teams increasingly rely on digital tools, such as videoconferencing platforms, collaborative document systems, and asynchronous communication channels, to coordinate tasks, exchange information, and pursue shared goals (Handke et al., 2026). Virtual interaction has therefore become a defining feature of modern teamwork rather than a supplemental or temporary arrangement. This evolution raises important questions about how team processes unfold when face-to-face interaction is limited or replaced by technology-mediated communication.

In this context, understanding the role of virtuality in shaping team dynamics, effectiveness, and outcomes has become crucial (Purvanova & Kenda, 2022). Team virtuality can be conceptualized as a continuum that reflects the degree to which team members use communication media to coordinate their actions and perform their tasks (Dixon & Panteli, 2010). As organizations increasingly adopt hybrid work models, teamwork has likewise become more hybrid, with many teams operating at different points along the spectrum between "never" and "always" meeting face-to-face (Cousins et al., 2007; Handke et al., 2026).

Research on the effects of team virtuality on team effectiveness has mostly focused on performance and has produced contradictory results (Purvanova & Kenda, 2022). While some studies show that team virtuality contributes to performance by increasing available resources, others point out that team virtuality hinders communication and cooperation, which in turn leads to a decrease in performance levels (Zheng et al., 2024).

In this study, we go beyond the commonly studied dimension of team effectiveness (i.e., team performance) to explore other equally important and less studied criteria (Hackman, 1987). Specifically, we intend to contribute to clarifying how virtuality impacts team innovation (i.e., the intentional introduction and adoption of new ideas and solutions in the group) and team member satisfaction (i.e., an affective response of members toward the group, its characteristics and functioning) through its influence on teamwork management.

Teamwork management refers to the way team members organize themselves to plan their tasks and perform their work with the aim of enhancing overall team effectiveness (Rousseau et al., 2006). According to Rousseau and colleagues, teamwork management includes the following dimensions: work planning/organization, resource management and support for innovation dimensions. Work planning involves coordinating and scheduling tasks to ensure they are completed efficiently and within established deadlines. Resource management concerns how team members use and distribute available resources, strategically allocating them to achieve desired goals and outcomes. Support for innovation reflects the extent to which the team encourages the generation of new ideas and practices, as well as their practical implementation and adoption within the group.

Drawing on conservation of resources theory (COR; Hobfoll et al., 2018), virtuality can be understood as a condition that simultaneously facilitates resource gains and exposes individuals to potential resource losses (Zhang et al., 2024). In terms of gains, virtual work often expands access to information through shared digital platforms, increases transparency of work processes, and provides employees with greater flexibility in managing their tasks and schedules (Handke et al., 2025). These benefits can enhance efficiency and reduce time pressures, thereby enriching individuals' resource pools.

At the same time, virtuality can create conditions that drain resources. Technology-mediated communication may limit spontaneous interaction and reduce the richness of social cues, making it more difficult to build trust, coordinate tasks smoothly, or maintain strong interpersonal relationships (Carter et al., 2019). These challenges can weaken collaboration and increase the cognitive effort needed to interpret messages or resolve misunderstandings. Thus, virtuality introduces a dynamic interplay of resource gains – such as increased information availability – and resource losses – such as diminished collaboration and social connectedness (Zhang et al., 2024).

Individuals working in virtual environments are motivated to engage in behaviours that help them obtain additional resources while safeguarding those they already possess (Hobfoll et al., 2018). Therefore, when team virtuality increases, team members are likely to invest more effort in team management behaviours – that is, behaviours aimed at structuring, coordinating, and supporting collective work processes – to obtain the benefits of working virtually (Rousseau et al., 2006).

These behaviours become especially important in virtual contexts that require deliberate coordination through digital tools, where clarity of roles, timelines, and expectations must be intentionally constructed rather than emerging organically. Research on virtual teamwork emphasizes that effective planning, transparent communication, and shared monitoring help reduce ambiguity and maintain high-quality interaction even when team members are geographically dispersed (Handke et al., 2025). Such behaviours function simultaneously as resource-protective strategies – preventing misunderstandings, delays, or interpersonal strain – and as resource-building strategies, enabling access to information and strengthening team cohesion.

Team management behaviours are well-established predictors of team effectiveness. Rousseau et al. (2006) argue that coordinated planning, mutual support, and efficient resource allocation facilitate not only smoother task execution but also promote a shared understanding of goals and interdependencies. When team members engage in these behaviours consistently, they create a structured and supportive team environment that enhances members' confidence in their collective capabilities. This structured teamwork environment is particularly valuable in virtual teams, where coordination and communication require more intentional effort (Purvanova & Kenda, 2022).

By planning tasks effectively, supporting one another, and distributing resources strategically, teams cultivate positive attitudes among members, reflected in higher individual satisfaction. Such attitudes emerge because well-managed teamwork reduces stressors, increases predictability, and fosters a sense of belonging and mutual reliability, resources that are especially important when physical distance limits informal social interaction (Mahadevan, 2024). Moreover, teamwork management also creates

the psychological and cognitive conditions necessary for innovation (Rousseau et al., 2006) When teams manage their work effectively, they free up cognitive resources that can be redirected toward creative thinking, exploration of new ideas, and collective problem-solving.

Thus, as virtuality increases, teams will tend to invest more in team management behaviours not only to avoid the negative effects of resource losses but also to leverage resource gains, ultimately enhancing both individual satisfaction and team innovation. Therefore, the following hypotheses are proposed:

H1: Team virtuality has an indirect relationship with team members' satisfaction through teamwork management.

H2: Team virtuality has an indirect relationship with team innovation through teamwork management.

Our conceptual model is depicted in Fig. 1.

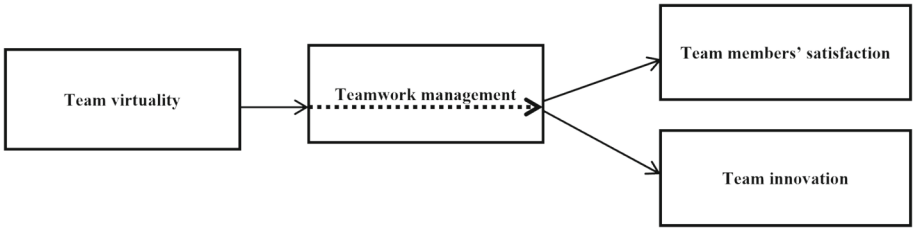

Fig. 1. Hypothesized model under analysis

2 Materials and Methods

2.1 Procedure and Sample

Organizations were identified using both the authors' personal and professional networks and national company databases that are accessible online. Data were collected through surveys, which were mostly completed online (in a few cases, surveys were completed on paper). To mitigate common method variance (Podsakoff et al., 2003), we employed a two-wave data collection approach with a two-month interval between measurements. Team virtuality and teamwork management was collected in the first wave, while team innovation and team member satisfaction was collected in the second wave. This time frame was strategically chosen to balance two objectives: minimizing common method bias while ensuring the interval remained sufficiently brief for the hypothesized antecedents to potentially influence the outcome variable. In addition, data were obtained from two sources: team members were surveyed about team virtuality, teamwork management and individual satisfaction, while team innovation was obtained from the leader.

The sample is composed of 358 members from 88 teams from different companies. Team size varied from 3 to 43 members with an average of approximately six members (SD = 5.37) and teams have been working together for about eight years (SD = 10.50). Teams developed different types of activities, most of them were services teams (46%).

2.2 Measures

To measure team virtuality, we used the indicator proposed by De Jong et al.'s (2008), which is based on the criteria of Baltes et al. (2002) that consider three factors: (a) the frequency of technology use, (b) the degree of synchronisation, and (c) the presence of nonverbal and para verbal signs. Team members are asked to provide the percentage of use (up to 100%) of different modes of communication in team interactions in the last month (including options such as in-person, video conference, conference call, and chat). Then, the equation proposed by the authors is implemented (see De Jong et al., 2008). Finally, the results obtained are subtracted from 100% to give the level of virtuality. Higher values indicate a greater degree of virtuality.

Teamwork management was measured using the scale developed by Rousseau et al., (2006), which is composed of six items that are measured using a 5-point Likert-type scale, from 1 (not true) to 5 (completely true). A sample item is "We organize our work activities".

To measure team member satisfaction, we used the scale developed by Dimas and Lourenço (2015). This scale is composed of seven items that measure members' satisfaction with different aspects related to the team. A sample item is "team functioning". Statements are evaluated on a 7-point Likert-type scale ranging from 1 (totally dissatisfied) to 7 (totally satisfied).

Finally, team innovation was measured through the three-item scale of Batarseh et al. (2017), which, in turn, was based on the two-item scale of Vera and Crossan (2005). The responses are evaluated on a Likert scale ranging from (1) totally disagree to (7) totally agree. A sample item is: "The team frequently introduces new product/service innovations."

Team size and team tenure were considered as control variables in the present study, as previous research has shown that these variables may influence team outcomes (Standifer et al., 2015; West & Andreson, 1996). As some teams were surveyed before the start of the COVID-19 pandemic (2020) and others during the pandemic (2021, 2022), a dummy variable (0 = surveyed before the pandemic; 1 = surveyed during the pandemic) was introduced to account for the possible influence of the pandemic crisis on the outcome variables.

3 Results

3.1 Data Aggregation

Since teamwork management was operationalized at the team level but obtained at the individual level using referent shift consensus (Chan, 1998), within-team homogeneity and between-team heterogeneity need to be assured. Accordingly, we calculated the inter-rater reliability index r_{wg} (James et al., 1993) and the intra-class correlation coefficients ICC (1) and ICC (2) (Bliese, 2000).

The r_{wg} index relates the within-group variance of a single item *j* in a group of K raters (S^2_{jk}) to an expected variance that assumes all ratings were due to random responding

(σ^2_{EU}). Since our scales have multi-items, $r_{wg(j)}$ was implemented which is given by the following formula:

$$r_{wg(j)} = \frac{J \times \left(1 - \frac{S^2_{jk}}{\sigma^2_{EU}}\right)}{1 + (j-1) \times \left(1 - \frac{S^2_{jk}}{\sigma^2_{EU}}\right)}$$

Following Bliese (2000), *ICC (1)* was calculated using Bartko (1976) formula:

$$ICC(1) = \frac{MSB - MSW}{MSB + [(k-1) \times MSW]}$$

MSB is the between-group mean square, *MSW* is the within-group mean square, and K is the group size. This formula is a way of contrasting the between-group and within-group variance components from the ANOVA model. Since group sizes were different among teams, the group size average was used. While *ICC (1)* may be considered as a measure of the reliability associated with a single assessment of the group mean, *ICC (2)* provides an estimate of the reliability of the group means and is given by the following formula (Bliese, 2000):

$$ICC(2) = \frac{MSB - MSW}{MSB}$$

The results showed adequate average r_{wg} values for teamwork management (M = .89, SD = .21), well above the recommended cut-off of point of.70 (James et al., 1993). The results for *ICC* (1) and *ICC* (2) for teamwork management were.30 and.67, respectively, also revealing adequate results. Taken together, the r_{wg}, *ICC* (1) and *ICC* (2) values provide sufficient justification for aggregating the data to the team level.

3.2 Measurement Model Assessment

We conducted a confirmatory factor analysis on Stata (version 16), using the maximum likelihood method of estimation to ensure that the latent variables under study presented adequate convergent and discriminant validity. The three-factor measurement model showed adequate results ($\chi 2$ (101) = 354.06, $p < .001$, TLI = .94, CFI = .95, RMSEA = .08). Internal consistency was assessed via Cronbach's alpha (α), which exceeded.70 for all measures (cf. Table 1).

3.3 Hypothesis Testing

Descriptive statistics and intercorrelations among studied variables are presented in Table 1. Regarding control variables, team tenure was negatively and significantly related to team member satisfaction ($r = -.22$, $p < .01$), to teamwork management ($r = -.26$, $p < .01$), as well as to team innovation ($r = -.17$, $p < .01$). Teams collected during the pandemic presented higher levels of team virtuality ($r = .56$, $p < .01$), teamwork management ($r = .22$, $p < .01$), team member satisfaction ($r = .11$, $p < .05$) and team

innovation ($r = .14$, $p < .01$). Team size was negatively and significantly related to team innovation ($r = -.32$, $p < .01$), but not with teamwork management and team member satisfaction. Therefore, team size was only included as a control variable in the estimation of team innovation, while team tenure. Team virtuality was positively related to teamwork management ($r = .28$, $p < .01$) and to team member satisfaction ($r = .10$, $p < .05$) while the correlation with team innovation was not significant ($r = -.05$, *ns*). Teamwork management was positively related to team innovation ($r = .22$, $p < .01$) and to team member satisfaction ($r = .33$, $p < .01$).

Table 1. Descriptive statistics and intercorrelation matrix.

Variable	1	2	3	4	5	6	7	*M*	*SD*
1. Team tenure	–							8.72	10.76
2. Team size	−.04							8.53	7.72
3. Pandemic situation	.03	.03						–	–
4. Team virtuality	−.15**	.04	.56**					44.45	16.36
5. Teamwork management	−.26**	−.01	.22**	.28**	(.94)			3.95	.50
6. Team innovation	−.17**	−.32**	.14**	−.05	.22**	(.89)		5.04	1.09
7. Team member satisfaction	−.22**	.03	.11*	.10*	.33**	.15**	(.94)	5.60	1.00

Note: N = 358 members/88 teams. *p < .05; **p < .01. *M* = Mean; *SD* = Standard Deviation; Pandemic situation (0 = before the pandemic; 1 = after the beginning of the pandemic). Team member satisfaction and team innovation were collected two months after the remaining variables. Cronbach's alphas are provided between brackets.

Data for this study is hierarchical in nature since we are interested in exploring the effect of two variables that are operationalized at the team level, team virtuality and teamwork management, on one variable from the individual level, team member satisfaction and one variable from the team level, team innovation.

Because individuals within the same group are exposed to shared influences, applying ordinary regression analysis may produce unreliable estimates; this is because the assumption of independent observations would be violated (Bryk & Raudenbush, 1992). Therefore, we need to explore the need to consider the influence of the group on team member satisfaction, by computing the intraclass correlation coefficient (Bliese, 2000). Therefore, the initial step involves decomposing the variance in team member satisfaction (σ^2) into within-group and between-group components. If the results show that only a small proportion of the variance (typically less than 5%) lies between groups, then ordinary regression analysis is appropriate (Heck et al., 2013). *ICC* is computed as

follows:

$$ICC = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_w^2},$$

where σ_b^2 is the between-group variance and σ_w^2 is the within-group variance. The ICC value confirmed that 34% of the variance in member's satisfaction is explained by team membership, suggesting the need to use Hierarchical Linear Modelling to test hypotheses. Thus, we tested our hypothetical model through generalized structural equation modelling (GSEM) with Stata (version 16), including a random intercept in the equation predicting team member satisfaction to account for group membership. Additionally, variables were grand-mean centred, except for the outcome variables, a suitable method for mediational models with a nested structure (Kreft et al., 1995).

Results of GSEM analysis are presented in Table 2. Team virtuality presented a positive relationship with teamwork management ($B = .005$, $p < .01$). Teamwork management presented a positive effect on both team member satisfaction ($B = .54$, $p < .001$) and team innovation ($B = .41$, $p < .001$). To test hypothesis 1 and 2, we computed the indirect effect of team virtuality on team member satisfaction and team innovation, respectively. Results for team member satisfaction revealed that the indirect effect was significant (B = .003, $p < .05$, 95% CI = .0003; .005) providing support for hypothesis 1. Regarding team innovation, the indirect effect was also significant supporting H2 (B = .002, $p < .05$, 95% CI = .0002; .004).

Table 2. Generalized structural equation modelling analysis.

Predictor variables	Teamwork management	Member's satisfaction	Team innovation
Team tenure	−.01***	.01*	−.02***
Pandemic	.14*	.08	.55***
Team size			−.05***
Team virtuality	.005**	−.00	−.02***
Teamwork management		.54***	.41***
var(M1[Group])	.21		
var(e.teamwork management)	.22		
var(e.team innovation)	.95		
var(e.team member satisfaction)	.68		
Log-likelihood	−1197.54		

Note. The random intercept was included in the path analysis. *p < .05; **p < .01.; ***p < .001.

4 Discussion and Conclusions

In the present study, we examined how team virtuality influences team effectiveness, specifically, team member satisfaction and team innovation, through its impact on teamwork management processes. We draw on Conservation of Resources (COR) theory (Hobfoll, 1989; Hobfoll et al., 2018), which argues that individuals are motivated to protect, retain, and invest resources that enable them to function effectively at work. Virtuality constitutes a dual-edged condition in this framework: it generates resource gains (e.g., increased flexibility, broader access to information, reduced spatial constraints), but simultaneously introduces resource loss risks (e.g., reduced social cue richness, heightened ambiguity, greater coordination demands) (Carter et al., 2019; Zhang et al., 2024). COR theory posits that when individuals perceive potential or actual loss, they engage in compensatory resource-investment strategies to counteract those losses and secure future gains (Halbesleben et al., 2014).

Applying this logic to virtual teamwork, we argued that higher levels of virtuality would prompt team members to invest more heavily in teamwork management behaviours, such as work planning, resource coordination, clarifying responsibilities, and providing mutual support, to protect themselves from the potential depletion of cognitive and relational resources that virtual work can impose. This reasoning is consistent with broader team-effectiveness theorizing, which identifies coordination, communication structuring, and supportive behaviours as foundational processes that strengthen collective functioning in complex or uncertain environments (Mathieu et al., 2008; Rousseau et al., 2006).

Our findings support these predictions: as virtuality increased, so did the extent to which teams engaged in teamwork management behaviours, which acted as a critical mechanism linking virtuality to team outcomes. By structuring work, allocating resources efficiently, and maintaining shared support systems, teams were able to reduce ambiguity and coordination strain, conditions known to undermine satisfaction and impede creative work (Hülsheger et al., 2009; Mathieu et al., 2008). At the same time, effective teamwork management freed up cognitive resources and fostered psychological safety, both of which enable exploration, idea generation, and innovation implementation (Edmondson, 1999) and create a positive climate that, in turn, will contribute to increasing the levels of team member satisfaction.

Summing up, our study advances the literature on team virtuality by shedding light on the underlying mechanisms through which virtuality shapes team effectiveness (i.e., team member satisfaction and team innovation). Although previous research has examined the outcomes of virtuality, the pathways through which these effects occur have received far less attention. To the best of our knowledge, this is the first empirical study to test the indirect influence of team virtuality on multiple dimensions of team effectiveness via teamwork management.

Our results highlight that teamwork management constitutes a central process through which teams can buffer the challenges and leverage the opportunities associated with virtual collaboration. Effective planning, clear structuring of tasks, strategic allocation of resources, and mutual support are not merely beneficial, they are foundational for sustaining high levels of satisfaction among members and fostering the conditions that allow innovative ideas to emerge and be implemented (Rousseau et al., 2006).

From a practical standpoint, the findings highlight the importance of equipping managers and team leaders with the skills needed to coach and support teams working at higher levels of virtuality. Specifically, managers should help teams develop strong routines for planning and organizing their work, clarifying responsibilities, and monitoring progress. Such practices become especially crucial when face-to-face interaction is limited, as they provide the structure and predictability that virtual teams need to maintain engagement, collaborate effectively, and innovate.

The results of this study should be considered with a number of limitations. Although we used a two-wave data collection procedure, team virtuality and teamwork management were collected at the same time, despite the fact that we are testing a mediational process. However, it is important to highlight that team virtuality was assessed retrospectively, based on the preceding month's data, whereas the time reference for teamwork management was the current time. This temporal distinction helps to partially mitigate concerns about causal order. Secondly, the limited sample size at the team level ($n = 88$) may impact the statistical power and generalizability of the results. Future studies should aim to replicate these findings with larger samples. It would also be interesting to consider some moderators, such as emotional management or trust.

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